t range to 400μV and is recom-
quiring high null resolution.
TCV_{OS} performance.

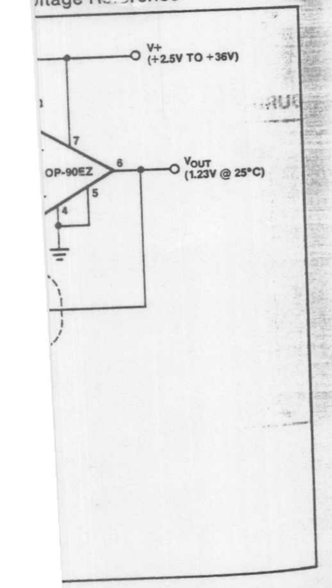
OLTAGE RANGE
he OP-90's input and output
allows true "zero-in, zero-out"
rovides an active pull-down to
low this level, a load resistance
iired to pull the output down to

.8V the OP-90 has voltage gain
cation. Output current source
he entire voltage range includ-

GE REFERENCE
ery-powered voltage reference
y current. At this level, two AA
over 18 months. At an output
rift of the reference is only
nperature range. Load regula-
lation at 120μV/V.

ed on the bandgap technique
produces unequal currents in
mismatch creates a tempera-
ss R3 which, in turn, produces
nal voltage across R4 and R5
itput added to the V_{BE} of Q1
ture coefficient. Adjusting the

ltage Reference



REV. B

output to 1.23V at 25°C produces minimum drift over temperature. Bandgap references can have start-up problems. With no current in R1 and R2, the OP-90 is beyond its positive input range limit and has an undefined ouput state. Shorting Pin 5 (an offset adjust pin) to ground forces the output high under these conditions and insures reliable start-up without significantly degrading the OP-90's offset drift.

SINGLE OP AMP FULL-WAVE RECTIFIER

Figure 5 shows a full-wave rectifier circuit that provides the absolute value of input signals up to ±2.5V even though operated from a single 5V supply. For negative inputs, the amplifier acts as an unity gain inverter. Positive signals force the op amp output to ground. The 1N914 diode becomes reversed-biased and the signal passes through R1 and R2 to the output. Since output impedance is dependent on input polarity, load impedances cause an asymmetric output. For constant load impedances, this can be corrected by reducing R2. Varying or heavy loads can be buffered by a second OP-90. Figure 6 shows the output of the full-wave rectifier with a $4V_{p-p}$, 10Hz input signal.

FIGURE 5: Single Op-Amp Full Wave Rectifier

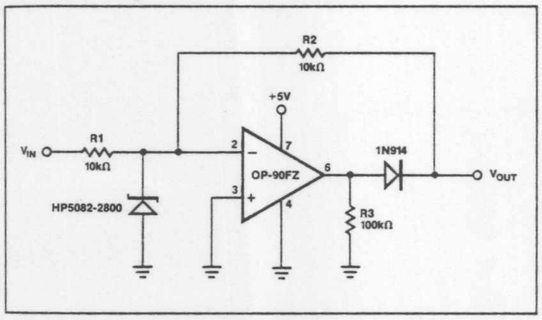
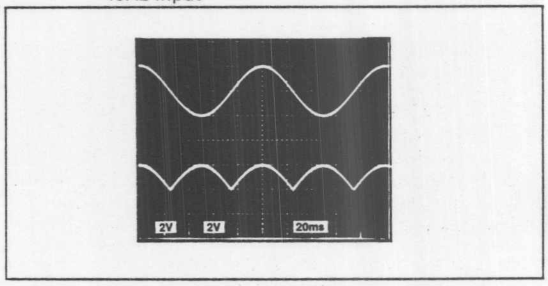


FIGURE 6: Output of Full-Wave Rectifier With $4V_{p-p}$, 10Hz Input



TWO WIRE 4-20mA CURRENT TRANSMITTER

The current transmitter of Figure 7 provides an output of 4mA to 20mA that is linearly proportional to the input voltage. Linearity of the transmitter exceeds 0.004% and line rejection is 0.0005%/volt.

Biasing for the current transmitter is provided by the REF-02EZ. The OP-90EZ regulates the output current to satisfy the current summation at the noninverting node:

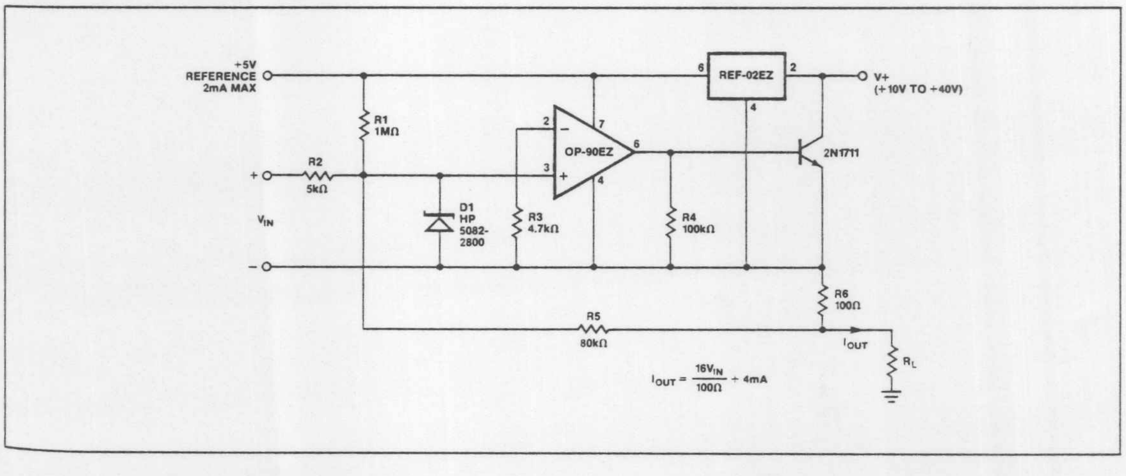
$$I_{OUT} = \frac{1}{R6}\left(\frac{V_{IN}\,R5}{R2} + \frac{5V\,R5}{R1}\right)$$

For the values shown in Figure 7,

$$I_{OUT} = \left(\frac{16}{100\Omega}\right)V_{IN} + 4mA$$

giving a full-scale output of 20mA with a 100mV input. Adjustment of R2 will provide an offset trim and adjustment of R1 will provide a gain trim. These trims do not interact since the noninverting input of the OP-90 is at virtual ground. The Schottky diode, D1, prevents input voltage spikes from pull-

FIGURE 7: Two Wire 4-20mA Transmitter



2

ing the noninverting input more than 300mV below the inverting input. Without the diode, such spikes could cause phase reversal of the OP-90 and possible latch-up of the transmitter. Compliance of this circuit is from 10V to 40V. The voltage reference output can provide up to 2mA for transducer excitation.

MICROPOWER VOLTAGE-CONTROLLED OSCILLATOR

Two OP-90s in combination with an inexpensive quad CMOS switch comprise the precision VCO of Figure 8. This circuit provides triangle and square wave outputs and draws only 50μA from a single 5V supply. A1 acts as an integrator; S1 switches the charging current symmetrically to yield positive and negative ramps. The integrator is bounded by A2 which acts as a Schmitt trigger with a precise hysteresis of 1.67 volts, set by resistors R5, R6, and R7, and associated CMOS switches. The resulting output of A1 is a triangle wave with upper and lower levels of 3.33 and 1.67 volts. The output of A2 is a square wave with almost rail-to-rail swing. With the components shown, frequency of operation is given by the equation:

$$f_{OUT} = V_{CONTROL}\ (\text{volts}) \times 10\text{Hz/V}$$

but this is easily changed by varying C1. The circuit operates well up to a few hundred hertz.

FIGURE 8: Micropower Voltage Controlled Oscillator